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SUBJECT: Authorization for Release of Technical Information, Contr^l Number: **AFRL-PR-ED-TP-1998-084**
T.C. Miller (SPARTA) "Adhesive Layer Effects on Interfacial Crack . p Asymptotic Fields"
EXTENDED ABSTRACT

(Statement A)

Adhesive Layer Effects on Interfacial Crack Tip Asymptotic Fields

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Interfacial cracks in layered materials are frequently modeled without considering the presence of an adhesive layer. The validity of this approach depends on factors such as the adhesive layer thickness and properties. In this work, adhesive layer effects are studied by introducing a thin layer into existing computational models and determining the effects on the near tip stress and strain behavior as the adhesive modulus is varied.

The models presented here simulate a set of related photoelastic stress freezing experiments. A typical finite element model is shown in Figure 1. The nominal remote loads were 96.5 kPa in all cases. Different crack orientations (0, 15, 30, and 45 degrees) were used to create different levels of mode mixity. These experiments used three materials, a photoelastic material (araldite), a composite of araldite and aluminum powder, and a thin layer of adhesive. The moduli for the materials (above the stress freezing temperature) were 18.6, 37.2, and 41.4 MPa, respectively. Because in this instance the adhesive layer was thin (approximately 0.20 mm) and had properties similar to the araldite/aluminum material, its effect on the crack tip fields was not significant.

The current work examines the effects of the adhesive layer by systematically varying the modulus in a thin layer of adhesive (0.40 mm) and studying the effects on the field variables near the crack tip. The adhesive layers have moduli that vary from 0.7 to 41.4 MPa, so that a range of situations is considered from adhesives that are relatively weak to those that are comparable to the other two materials.

Figure 2 shows the results for the J integral values as a function of adhesive layer modulus. The J values are determined using the domain integral method, which uses an area integral that is equivalent to the contour integral. The figure shows that the J values decrease rapidly to some asymptotic value for each crack orientation, so that above some relatively weak modulus (about 7 MPa) the adhesive layer has no effect. For comparison, the figure also shows calculations for models that use only two materials and exclude any adhesive layer. These values lie along the asymptotes, indicating that the bimaterial assumption is viable except in situations where a relatively weak adhesive layer is present.

Figure 3 shows the maximum shear stress contour plots for various crack orientations when the adhesive layer modulus is 0.7 MPa. In these instances the weak adhesive layer causes large shear deformations whenever mixed-mode loading is present. The large deformations cause the higher J values found in Figure 1, and also cause changes in the near tip stress fields. The adhesive layer can only support small stresses, so a large band of low shear stresses is found in the adhesive. The related near tip stress fields are also altered; the asymmetry in the fringe patterns is increased compared to the adhesive free bimaterial specimen. Similar results are found for the in-plane shear stress and strains.

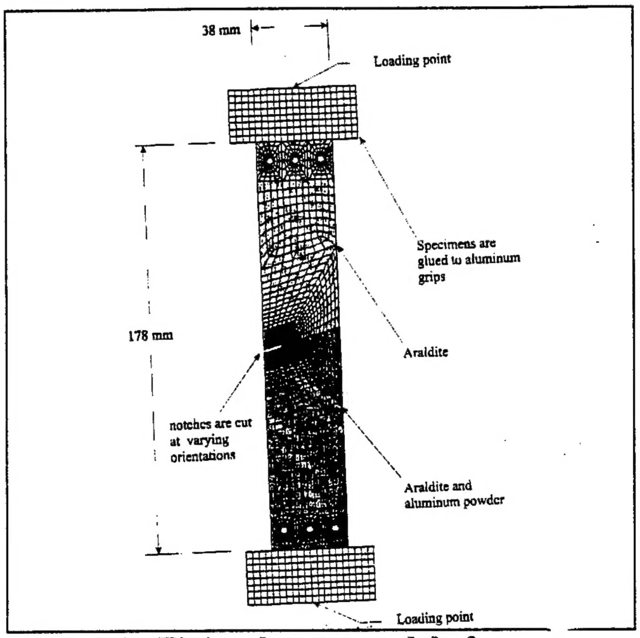

Figure 1 - Finite element model of a photoelastic specimen

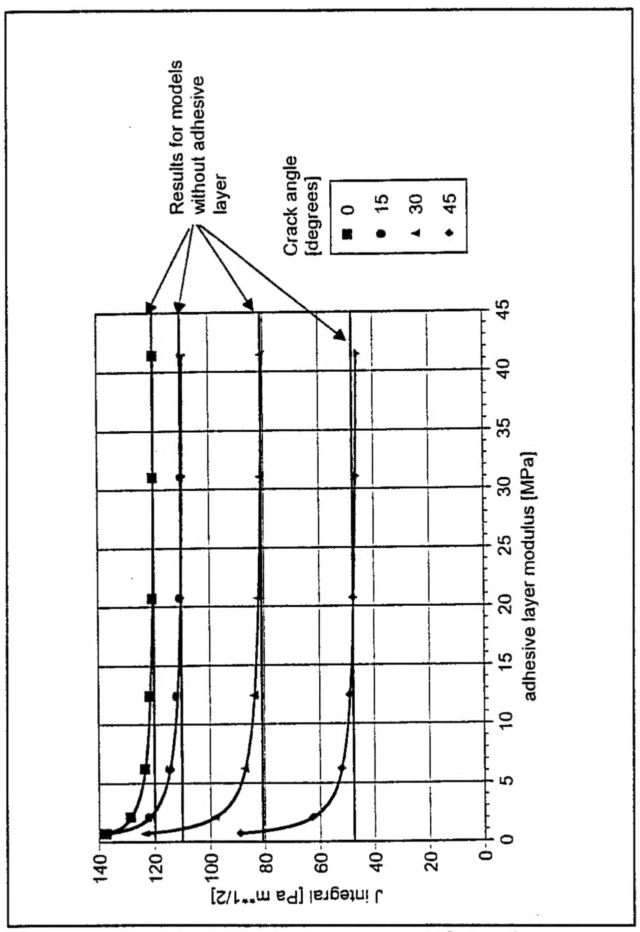

Figure 2 - J integral values as a function of adhesive modulus

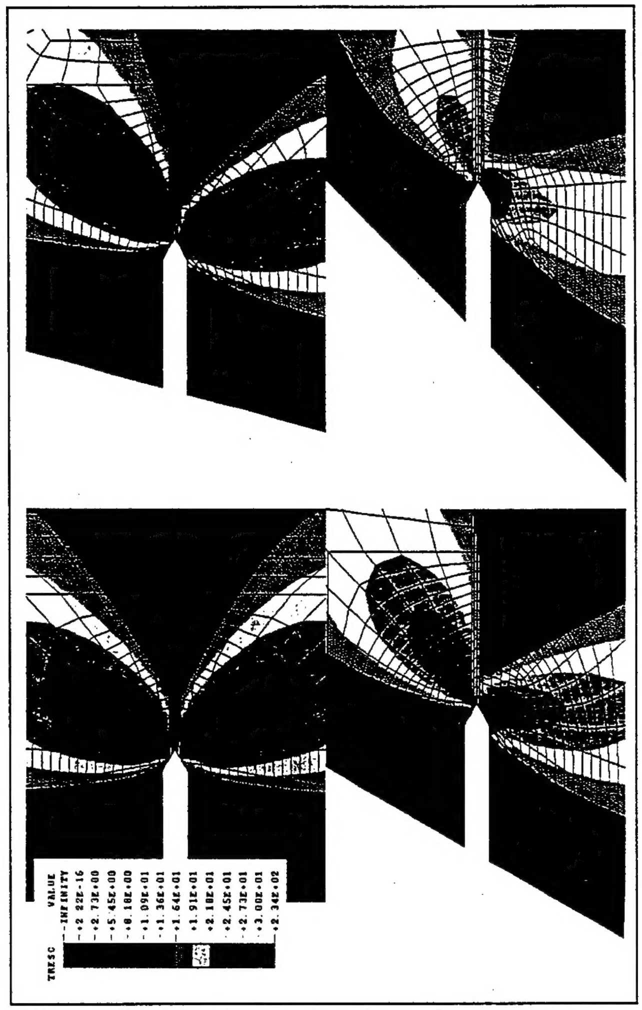

Figure 3 - Maximum in-plane shear stress with a weak adhesive layer (various mode mixities)